Christ Church Grammar School

Year 12 Chemistry

Volumetric analysis validation test 2021

Name: ANSWERS

Mark = .../40

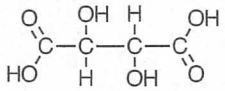
Question 1 **(30 marks)**

Winemakers often use grape juice concentrates in their winemaking efforts. The concentrates are versatile as a basic material for the final product and also as a supplement to improve flavour. They are prepared by boiling grapejuice under pressure. The concentrates contain the same acids as those found in wine.

One such concentrate was found to have an average acid content of 43.6 gL^{-1}. To accurately determine the acid content of the concentrate, titration with sodium hydroxide solution was used.

The standardised sodium hydroxide had a concentration 0.105 $molL^{-1}$. The assumption was made that all the acid present was tartaric acid.

The structure of tartaric acid is shown below.



Tartaric acid is a diprotic weak acid. Refer to it as H_2Ta for the purposes of this question.

(a) The concentrate requires dilution prior to titration. Using calculations, determine the appropriate dilution.

$[H_2Ta] = 43.6 / 150.048$ $M(H_2Ta) = 150.048\ g\,mol^{-1}$

$= 0.2906\ mol\,L^{-1}$

Titre volume should approximately = aliquot volume

$H_2Ta + 2OH^- \rightarrow 2H_2O + Ta^{2-}$

$[H_2Ta] = \frac{1}{2}[OH^-]$

$= .105/2$

$= .0525\ mol\,L^{-1}$

$\therefore$ Dilution factor $= .2906/.0525 = 5.5$

(5 marks)

(b) (i) Sodium hydroxide cannot be used as a primary standard and must be standardised by a series of titrations. Give three properties that a primary standard must have.

1. It must be obtainable in the pure form
2. Must not react with atmospheric (H_2O or air)
3. Should have a reasonably high molar mass

(3 marks)

(ii) Explain why sodium hydroxide cannot be used as a primary standard.

NaOH absorbs H_2O from the atmosphere / reacts with atmospheric CO_2 (1 only)

(1 mark)

(c) A group of students analysed the diluted wine by titration with the standard sodium hydroxide solution. **This group of students determined the concentrate needed to be diluted by a factor of 4. (not the real dilution factor)**

20.00 mL aliquots of the diluted wine concentrate in the conical flask required an average titre of 16.25 mL of the sodium hydroxide to reach the end point.

(i) Use the group's results to calculate the concentration of the tartaric acid in the concentrate in gL^{-1}.

$n(OH^-) = 16.25 \times 10^{-3} \times .105 = 1.70625 \times 10^{-3}$ mol

$n(H_2Ta)$ in 20 mL diluted wine $= 1.70625 \times 10^{-3} / 2 = 8.531 \times 10^{-4}$ mol

$[H_2Ta]$ " " " " $8.531 \times 10^{-4} / .02 = 4.2655 \times 10^{-2}$ mol L^{-1}

$[H_2Ta]$ in undiluted concentrate $= 4 \times 4.2655 \times 10^{-2}$ mol L^{-1}

$= 1.7062 \times 10^{-1}$ mol L^{-1}

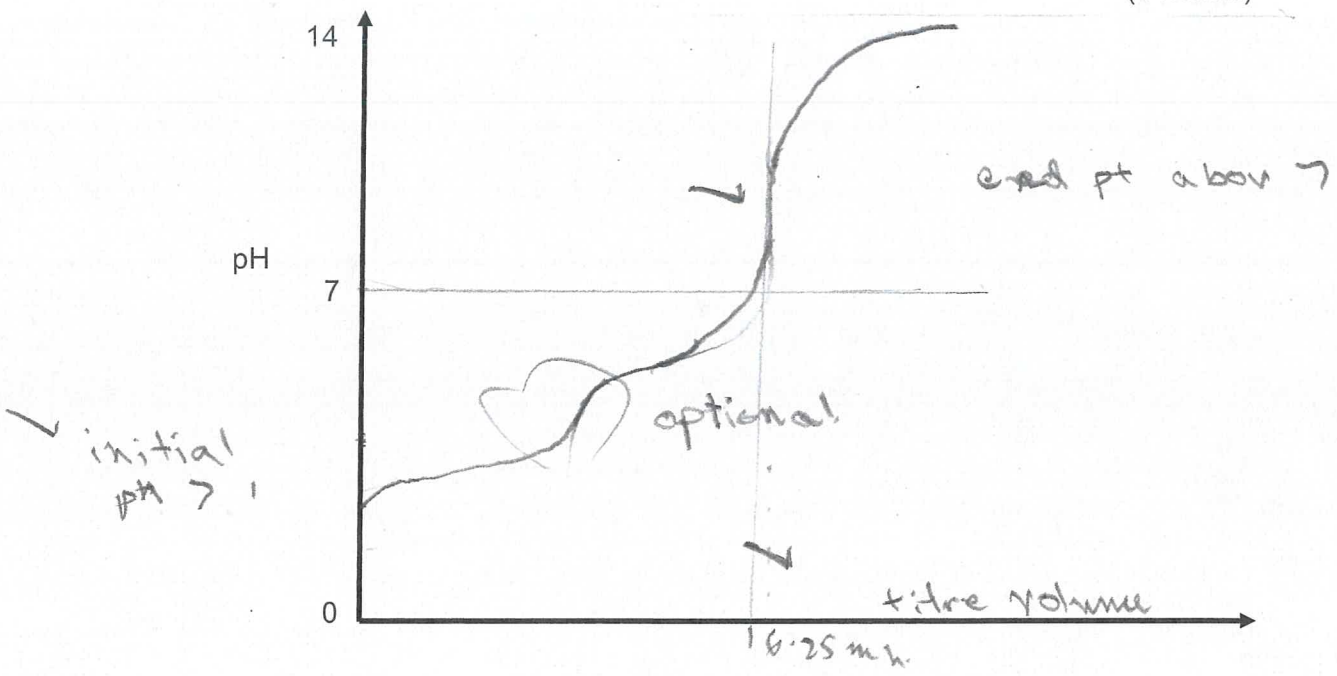
$[H_2Ta]$ in $gL^{-1} = 1.7062 \times 150.048$

$= 25.6$ gL^{-1}

(5 marks)

(e) On the axis below, sketch a graph showing how the pH would be expected to change during the titration, until an excess of the sodium hydroxide was added.

(3 marks)



Volume of NaOH Added (mL)

(f) Below is a list of indicators that the students considered when designing their analysis.

indicator	pH range	Colour change
Bromothymol blue	6.2 – 7.6	Yellow → blue
Tropaeolin	0.2 – 1.5	Purple → Red
Thymol Blue	8.0 – 9.6	yellow → blue

Select the most appropriate indicator and explain your choice with the use of relevant equations.

Thymol blue. $Ta^{2-} + H_2O \rightleftharpoons HTa^- + OH^-$

At equivalence pH > 7

Indicator colour change must be in the basic range.

(4 marks)

(g) Methyl orange indicator changes colour in the pH range 3 – 4.2. Explain the effect on the final calculated value for the tartaric acid concentration if methyl orange was used to identify the end point.

Titre volume would be less
n(OH⁻) used would be less
n(H_2T_a) and concentration would be less

(3 marks)

(h) Another group of students conducting the same experiment mistakenly rinsed their burette with the diluted wine. Explain how this would affect their final calculated value of the tartaric acid concentration.

some of the OH^- would be used prior to titration
volume of OH^- titrated would be greater
n(OH^-) and H_2T_a in the 20mL aliquot would be greater
$[H_2T_a]$ would be greater

(4 marks)

(i) Give one random and one systematic error in this experiment.

Random
balance ±, pipette ± burette ± etc,

Systematic
calibration of equipment
parallax error in reading meniscus
(any reasonable answer)

(2 marks)

Question 2 **(10 marks)**

When soils containing iron pyrite (FeS_2) are exposed to air, the following reaction occurs.

$$2\ FeS_2(s) + 7\ O_2(g) + 2\ H_2O(l) \rightarrow 2\ Fe^{2+}(aq) + 4\ SO_4^{2-}(aq) + 4\ H^+(aq)$$

These types of soils are called acid sulfate soils. The groundwater associated with these soils discharges into lakes and rivers.

(a) What will happen to the pH of the groundwater.

$[H_3O^+]$ in the soil increases ∴ pH decreases.

(1 mark)

A titration was carried out on a sample of lake water, suspected of being contaminated with acid soils, to determine its pH.

A student placed a standardised solution of 5.00×10^{-3} $molL^{-1}$ NaOH in the burette.
The student then titrated the NaOH solution against 50.0 mL samples of the lake water and obtained the following results.

	Trial 1	Trial 2	Trial 3	Trial 4
Final burette reading (mL)	3.80	8.05	12.00	16.05
Initial burette reading (mL)	0.00	4.10	8.10	12.05
Volume of NaOH used (mL)	3.80	3.95	3.90	4.00

(b) Determine the average volume of NaOH used. (2 marks)

$3.95 + 3.90 + 4.00 / 3 = 3.95$ mL

(c) Assuming that the lake water is the only source of H^+ ions and that complete ionisation of the acid in the lake water has occurred, determine the pH of the lake water.

$n(OH^-) = 3.95 \times 10^{-3} \times .005 = 1.975 \times 10^{-5}$ mol

$n(H^+) = n(OH^-)$ $H^+ + OH^- \rightarrow H_2O$

$[H^+] = 1.975 \times 10^{-5} / .05 = 0.00395$ mol L^{-1}

$pH = -\log(0.00395) = 3.40$

(4 marks)

(d) Complete the following table

Equipment	Rinsed with	Correct / incorrect
Burette	Distilled water then 0.005 $molL^{-1}$ NaOH	✓
Pipette	Distilled water	✗
Conical flask	Distilled water	✓

(3 marks)